

# Specification

For

## NCSX Modular Coil

Autoclave Heating System Fabrication/Procurements

### NCSX-CSPEC-142-02-00

Prepared by: \_\_\_\_\_  
Steve Raftopoulos, Cognizant Engineer for Modular Coil Tooling

Concur: \_\_\_\_\_  
J. Chrzanowski, Cognizant Engineer for Modular Coil Winding &  
Assembly, WBS 142

Concur: \_\_\_\_\_  
D. Williamson, WBS Manager for Modular Coils, WBS 14

Concur: \_\_\_\_\_  
Judy Malsbury, NCXS QA Representative

Approved by: \_\_\_\_\_  
B. Nelson, Project Engineer for Stellarator Core Systems, WBS 1

**Controlled Document**

*This is a controlled document. Check the NCSX Procurement Web prior to use to assure that this document is current.*

## **1.0 SCOPE**

- 1.1 This document provides the requirements and specifications for the fabrication and/or procurement of the NCSX Modular Coil Autoclave heating system.
- 1.2 The heating system consists of the vessel strip heaters and their monitoring/control system; the circulating heated fluid system, and the vessel insulation.

## **2.0 APPLICABLE DOCUMENTS**

- 2.1 Fabrication Standards
  - 2.1.1 ENG-002 “Control of Measuring Test Equipment and Calibration”
  - 2.1.2 NEC (National Electrical Code)
  - 2.1.3 American Welding Society Structural Welding Code – Steel,
  - 2.1.4 PPPL procedure EM-002 in accordance with AWS D1.1
- 2.2 Testing Standards
  - 2.2.1 All power cables shall be megger tested with a 500-volt megger tester. Test shall be performed with calibrated and certified testing equipment. All cables shall be tested after installation is completed and prior to terminations. If any damage is observed or test results are not satisfactory (per Manufacturerer’s standards), cable shall be replaced and installed.
  - 2.2.2 See Step 4.0 for conformance requirements
- 2.3 Drawings
  - 2.3.1 The Autoclave heating and controls system shall be fabricated per the following drawings:
    - 2.3.1.1 SB144E001 AUTOCLAVE 300W TUNG HALOGEN LIGHTING
    - 2.3.1.2 SB144E002 AUTOCLAVE COMB MOT CTRL MS-1-ACLV
    - 2.3.1.3 SB144E003 AUTOCLAVE COMB MOT CTRL MS-2-ACLV
    - 2.3.1.4 SB144E004 AUTOCLAVE 2000W PRIMARY HTR 1-5
    - 2.3.1.5 SB144E005 AUTOCLAVE 2000W PRIMARY HTR 7-12
    - 2.3.1.6 SB144E006 AUTOCLAVE 2000W SECONDARY HTR 1-6
    - 2.3.1.7 SB144E007 AUTOCLAVE 2000W SECONDARY HTR 7-12
    - 2.3.1.8 SB144E008 AUTOCLAVE 2000W PRIMARY HTR 13-18
    - 2.3.1.9 SB144E009 AUTOCLAVE 2000W PRIMARY HTR 19-24
    - 2.3.1.10 SB144E010 AUTOCLAVE CRCLT HTR CTRL MS-4-ACLV
    - 2.3.1.11 SB144E011 AUTOCLAVE BLOWER CTRL MS-3-ACLV

- 2.3.1.12 SB144E012 120V, AC POWER RECEPTACLES CWD  
AUTOCLAVE CART #2
- 2.3.1.13 SB144E013 120V, 1 PH. AC POWER RECEPTACLES CWD,  
AUTOCLAVE
- 2.3.1.14 SD144E014 ONE LINE DIAGRAM
- 2.3.1.15 SD144E015 AUTOCLAVE METER #1 CWD
- 2.3.1.16 AD144E016 AUTOCLAVE METER #2 CWD
- 2.3.1.17 SD144E017 AUTOCLAVE AIR CIRCULATION MANUAL  
CNTRL & METER CWD
- 2.3.1.18 SD144E018 AUTOCLAVE LADDER DIAGRAM
- 2.3.1.19 SD144E019 AUTOCLAVE WIRING DIAGRAM
- 2.3.1.20 SE144E020 AUTOCLAVE CONDUIT AND WIREWAY  
LAYOUT, AUTOCLAVE SECTION AT ELEVATION 108'-6"
- 2.3.1.21 SE144E021 AUTOCLAVE CONDUIT AND WIREWAY  
LAYOUT, AUTOCLAVE SECTION AT ELEVATION 115'-6"
- 2.3.1.22 SD144E022 AUTOCLAVE HEATER LOCATOR AND  
DETAILS
- 2.3.1.23 SD144E023 AUTOCLAVE CART FABRICATION  
DRAWING
- 2.3.1.24 SD144E024 AUTOCLAVE THERMOCOUPLE LOCATOR  
DRAWING, ELEVATION VIEW
- 2.3.1.25 SD144E025 AUTOCLAVE JUNCTION BOX B-ACLV-02  
COVER CUTOUT
- 2.3.1.26 6000-B-52210-PL LP-495
- 2.3.1.27 6000-B-52211-PL PP-498
- 2.3.1.28 6000-B-52212-PL PP-499
- 2.3.1.29 6000-B-52213-PL PP-500

## 2.3.2 Documents

- 2.3.2.1 The fabricator shall be required to build a system that can be  
operated in compliance with PPPL ES & H-5008 Section 2

## 2.4.1 Parts list:

- 2.4.1.1 Qty. 2 "Omega" fuzzy logic temperature controller  
CN4800 series, P/N CN4812-R1-R2-AL1-RAMP  
Range 0-800 deg. C, J type thermocouple,  
PID autotune, dual display, programmable process alarm,  
1/8 DIN, contact output, accuracy +/-0.5%  
120v input
- 2.4.1.2 Qty. 2 "Omega" temperature/process indicators/scanners  
P/N DP474-T-C2, with data logging & RS-232  
communications, 6 inputs, window based software, accuracy 1  
deg., 6 inputs, J type thermocouple, 120v input  
With interface cable P/N DP470-C2-CABLE

- 2.4.1.3 Qty. 1 “Omega” deviation display controller,  
P/N CN884J-300C, J type thermocouple, mech. Relay output  
SPDT, front dial adjustment, 0-300 deg. C,  
Accuracy 2%, 120v input
- 2.4.1.4 Qty. 1 “Omega” temperature panel meter,  
P/N DP1632, type J thermocouple, 120v input
- 2.4.1.5 Qty. 1 “Omega” adjustable temperature switch/probe  
P/N TSW-75, range 115-175 deg. C
- 2.4.1.6 Qty. 15 “Omega” standard size thermocouple connectors,  
extra heavy duty P/N OGP-J-MF, -29 thru 220 deg. C  
Qty. 30 “Omega” OGP-J-F,
- 2.4.1.7 Qty. 1 “Omega” panel, P/N SJP-24-J  
2-rows of 12 type-J standard thermocouple female conn.
- 2.4.1.8 Qty. 200 ft. “Omega” multi-pair extension cable  
P/N 12JX20PP, 12 pair, 20 ga. J type thermocouple wire,  
Color coded with white and red pairs, 105 deg. Outer jacket
- 2.4.1.9 Qty. 500 ft. “Omega” single pair, extension grade  
thermocouple wire, P/N EXTT-J-20, 20 ga. Solid,  
200 deg. C insulated, white and red conductors with overall  
jacket.
- 2.4.1.10 Qty. 2 “Omega” audible temperature alarm P/N 70A-3,  
95db
- 2.4.1.11 Qty. 1 “Omega” compact controller with switch  
P/N CCD100N-105
- 2.4.1.12 “Omega” J-type thermocouples qty. and P/N as listed  
Qty. 2 P/N QD-AP-J-316E-12, air probe with over braid  
Qty. 2 P/N XCIB-J-5-2-10, hooded with over braid  
Qty. 8 P/N XCIB-J-4-4-10, bolt on with over braid  
Qty. 13 P/N SA1-J-72, self-adhesive
- 2.4.1.13 Qty. 3 “ILSCO” snapbloc power distribution blocks  
P/N LDB-22-350  
Qty. 1 P/N LDA-22-350
- 2.4.1.14 Qty. 2 “Square-D” full voltage contactors  
P/N SE02-V02, 90A continuous current rating, nema 3,  
600V
- 2.4.1.15 Qty. 1 “Sola/Hevi-duty” uninterruptible power supply,  
P/N 48F4380 or equiv. 700VA/420W, 120v input/120v output,  
surge protection, class-B
- 2.4.1.16 Qty. 2 “Ceramaseal” conflat flanged power feedthru  
P/N 8176-08-CF, bakeable to 450 deg. C, 4 conductors,  
Rated for 1KV, 15A, 1.33 dia.
- 2.4.1.17 Qty. 1000 ft. 3/c, 14 ga. 19 strands, silver plated copper wire,  
TFE insulated/TFE outer jacket, 150 deg. C operation temp.,  
200 deg. Max. temp. 600v, .25 max. dia.
- 2.4.1.18 Qty. 1 Granville-Phillips series 275 analog readout  
convectron vacuum gauge

- 2.4.1.19 Qty. 1 “Crouse-Hinds” arktite, 200A, 480v cable plug  
P/N AP20468, 3W, 4P, cable plug.
- 2.4.1.20 Qty. 1 “Crouse-Hinds” arktite, 60A, 480v cable plug  
P/N APJ6485, 3W, 4P, cable plug
- 2.4.1.21 Qty. 1 “general Electric” transformer, P/N 9T23B3872  
or equiv., 480v Delta primary, 208/120v Y secondary,  
30KVA, dry type, vented
- 2.4.1.22 Qty. 1 “Siemens” 480v, 125A frame, 3 pole, 18,000A.I.C,  
disconnect switch with 50A circuit breaker, nema 1
- 2.4.1.23 Qty. 2 “Siemens” 480v, 125A frame, 3 pole, 18,000A.I.C  
disconnect switch with 100A circuit breaker, nema 1
- 2.4.1.24 Qty. 1 “Siemens” 240v, 100A frame, 3 pole, 10,000A.I.C,  
disconnect switch with 100A circuit breaker nema 1
- 2.4.1.25 Qty. 1 “Siemens” Type-S1, main lug, 240v, 30 circuits,  
3 pole, 4 wire, 125A max. w/handle blocking device, surface  
mtg.
- 2.4.1.26 Qty. 2 “Siemens” Type-S2, main lug, 480v, 30 circuits  
3 pole, 125A max. w/handle blocking device for all branch  
circuits, surface mtg.
- 2.4.1.27 Qty. 1 “Siemens” Type-S2, main lug, 480v, 18 circuits  
3 pole, 125 A max. w/handle blocking device for all branch  
circuits, surface mtg.
- 2.4.1.28 Qty. 100 ft. 4/c-#4awg copper, portable cable, type SOW, 90  
deg. C jacket, 600v insulated
- 2.4.1.29 Qty. 200 ft. 4/c-#4/0 copper, portable cable, type-W, 90 deg.  
C jacket, 600v insulated
- 2.4.1.30 Qty. 1 “Hoffman” nema 12, junction box, wall mount,  
P/N A362412LP, 14 ga, steel, grey with interior panel
- 2.4.1.31 Qty. 1 “Hoffman” nema 12, junction box, wall mount,  
P/N A302408LP, 14 ga. Steel, grey, with interior panel
- 2.4.1.32 Qty. 1 “APT Mechanical” blower and motor, 600 deg. F  
rated, 17” dia. 2000 cfm. P/N GI-20-174-LS,
- 2.4.1.33 Qty. 2 “Chromalox” 12 k-watt medium temperature air duct  
heaters, 480v, 750 deg F rated, P/N 260849
- 2.4.1.34 Qty. 36 “Chromalox” 2000watt high temperature strip heater,  
P/N 142527, model #NS-3802, 480v
- 2.4.1.35 Qty. 2 “Ceramaseal” ten pair thermocouple conflat flanges  
w/ plug P/N 11978-02-CF, J-type, bakeable to 450 deg.C
- 2.4.1.36 Qty. 30 ea.”Ceramaceal” .062” socket pins  
P/N 11998-02-X (iron)
- 2.4.1.37 Qty. 30 ea. “Ceramaceal” .062” socket pins  
P/N 11998-01-X (constantan)
- 2.4.1.38 Qty. 2, “Square-D” pushbuttons P/N 9001KR12RRH1H1
- 2.4.1.39 Qty. 1, “Square-D” 3-position selector sw. type-K  
P/N 300T3Q/CL and 1-2 position selector sw. type-K  
P/N KS11BH2

- 2.4.1.40 Qty. 8 “Square-D” pilot lights, type-K, P/N KT1R31,  
1 P/N KT1A31, 1 P/N KT1G31
- 2.4.1.41 Qty. 72 “Omega” High Temperature ring terminals  
P/N RLNC-16, rated for 650 deg. F
- 2.4.1.42 Qty. 108, “Chromalox” element clamps,  
P/N 6933
- 2.4.1.43 Qty. 80 ft. of 4” x 4” steel wireway, nema 1, and assoc.  
fittings
- 2.4.1.44 Qty. 24 ft. of 6” x 6” steel wireway, nema 1, and assoc.  
fittings
- 2.4.1.45 Qty 3 “hoffman” nema 12, junction boxes, wall mount  
P/N A242408LP, 14 ga. Steel, grey, with interior panel
- 2.4.1.46 Qty. as required Conduit RGS, Clamps, hardware, wire,  
cable and misc. equipment at per dwgs.
- 2.4.1.47 Qty. 2, 500 scfm vacuum pumps, 480v, with starters  
(Supplied by PPPL)
- 2.4.1.48 Qty.1 “Omega” RMS scalable Current meter with alarm  
P/N DP25-CRMS-R

### 3.0 **REQUIREMENTS:**

#### 3.1 System Equipment and Definition

- 3.1.1 The autoclave vessel chamber houses materials that are cured at elevated temperatures, under pressures and/or vacuum. The autoclave heating system provides for the precise setting, adjustment and maintenance of the vessel temperature during the VPI process.

The Heating system consists of the following components:

##### 3.1.1.1 Tank Resistance Heating:

- 3.1.1.1.1 Thirty-six, 2-kwatt, resistance strip heaters, 480v, attached to the vessel exterior shell.
- 3.1.1.1.2 16 Thermocouple readouts
- 3.1.1.1.3 2 Temperature feedback controllers.
- 3.1.1.1.4 1.5” thermal insulation.

##### 3.1.1.2 Circulating Fluid Heating

- 3.1.1.2.1 Two, 12-kwatt duct heaters, 480v, 3 ph..
- 3.1.1.2.2 2500 scfm (nominal) high temperature blower, 208v 3ph..
- 3.1.1.2.3 1.5” duct insulation.

3.1.1.3 Control System for vessel exterior

3.1.1.3.1 Two programmable controllers with fuzzy logic and autotune wired for individually as stage 1 (24000 watts) and stage two (12000watts) heating control.

3.1.1.4 Control system for Fluid Heating

3.1.1.4.1 Manual set point controller

3.1.1.4.2 Independent display

3.1.1.5 Ground fault indication

3.1.1.5.1 Ground fault detection for vessel, provide Indication at 4 to 6 milliamps and warning.

3.1.1.6 Temperature Scanning and Recording

3.1.1.6.1 12-point datalogging of process temperature. Windows-based software and RS-232 communication

3.1.1.7 Vacuum System

3.1.1.7.1 Primary and Backup Vacuum Pump capable of achieving 10 to the minus 3 max.

3.1.1.7.2 Vacuum Analog display/controller

3.2 Characteristics and Requirements

The following performance characteristics shall dictate the design of “custom” components, or the selection of “off-the-shelf” components.

3.2.1 Autoclave Performance

1. Sustain 50 deg. C under vacuum for 24 hours.
2. Be capable of reaching an elevated temperature of 135 deg. C within 8 hours.
3. Sustain 135 deg. C for 16 hours.
4. Provide personnel indication of hot surface,
5. Provide Personnel alarms for over temp. and ground fault detection.

6. Operated with a supplied voltage of 480v, for all heaters. The heater power must be isolated from the control system and convenience power so in may be locked out for safety personnel access into the autoclave.

7. The blower must operate on 208v, 3 ph. and be independent of heaters.

8. Controls must operate on a UPS protected 120v, 1ph. power system.
9. All convenience power must be derived from an independent 208/120v, 3ph.
10. All power routed on or to the autoclave during personnel access inside the vessel must be GFCI protected.
11. Power equipment to be mounted on 2 carts. Cart #1 480v, Cart #2 208v/120v and control equipment.

### 3.2.2 Equipment Performance

#### 3.2.2.1 Blower capability

- 3.2.2.1.1 Capable of providing a minimum of 2000 scfm across a pressure drop of 5 inches water.  
Capable of operating continuously at a temperature of 600 degrees Fahrenheit.

#### 3.2.2.2 Resistance heaters

- 3.2.2.2.1 Capable of operating at a min. temperature of 392 degrees Fahrenheit.

#### 3.2.2.3 Duct heater

- 3.2.2.3.1 Capable of raising air temperature by 20 degrees Fahrenheit per cycle through the heater.

#### 3.2.2.4 Ducting

- 3.2.2.4.1 Capable of functioning at 392 degrees Fahrenheit.
- 3.2.2.4.2 Capable of withstanding 15”(water column) differential pressure.
- 3.2.2.4.3 Capable of flowing a minimum 2000 SCFM with a flow loss not greater than 5 inches water.

#### 3.2.2.5 Feedback controllers

- 3.2.2.5.1 Capable of controlling temperatures to within +/- 0.5%
- 3.2.2.5.2 Capable of automated autotune or manual control.

#### 3.2.2.6 Design Life

- 3.2.2.6.1 The resistance heating, blower system and control system must support 100 heating cycles of 20 deg. C to 150 deg. C

### 3.3 Design and Construction

The manufacturer shall use trained and qualified personnel and qualified written procedures (where applicable) in accordance with specified requirements and performance specified in section 2.3 and 3.2.

#### 3.3.1 Production Drawings

3.3.1.1 “The Autoclave heating system shall be fabricated and assembled in accordance with the drawings, parts list, and other documents listed in section 2.3.1 and 2.4.1.

#### 3.3.2 Standards of Manufacture

##### 3.3.2.1 Electrical terminations

3.3.2.1.1 Crimping, connectors & Terminal Block

3.3.2.1.2 Electrical insulation Min. 200 deg. F at vessel

3.3.2.1.3 National Electric Code

##### 3.3.2.2 Ducting

###### 3.3.2.2.1 Fabrication

3.3.2.2.1.1 Ducting should be constructed of metal, with fastened connections.

3.3.2.2.1.2 Seams should be sealed with appropriate tape to minimize air loss.

##### 3.3.2.3 Insulation

3.3.2.3.1 Tank insulation shall consist of 1.5” minimum thickness fiberglass.

3.3.2.3.2 Duct insulation shall consist of 1.5” minimum thickness fiberglass.

#### 3.3.3 Workmanship

3.3.3.1 Per instructions noted on PPPL issued documentation procedures and best shop practices shall be employed.

3.3.3.2 All electrical wiring and assembly must be performed by a qualified electrician with a minimum of 5 years experience.

3.3.3.3 All electrical work must conform to current NEC rules.

3.3.3.4 Welding of supports and Carts must conform to PPPL EM-002 in accordance with AWS D1.1

### 3.4 Documentation

3.4.1 Maintain and forward copies to the Operations center of all material tests, certifications and inspections, accumulated during the fabrication, setup and pre-operational testing phases.

#### 4.0 QUALITY CONFORMANCE

4.1 The following chart delineates the actions to be taken to verify the requirements listed in section 3

Requirement	Description	Verification	Remarks
<b>3.1</b>	<b>Sys. Equip. &amp; Definitions</b>		
3.1.1.1	Tank Resistance Heater	Inspection	Verify Part no. with Sec. 2.4.1
3.1.1.2	Circulating Fluid Heating	Inspection	Verify Part no. with Sec. 2.4.1
3.1.1.3	Control System, Vessel Exterior	Inspection	Verify Part no. with Sec. 2.4.1
3.1.1.4	Control System, Fluid Heating	Inspection	Verify Part no. with Sec. 2.4.1
3.1.1.5	Ground Fault Indication	Inspection	Verify Part no. with Sec. 2.4.1
3.1.1.6	Temp. Scann. And Recording	Inspection	Verify Part no. with Sec. 2.4.1
3.1.1.7	Vacuum System	Test	
<b>3.2</b>	<b>Characteristics &amp; Req.</b>		
Step 1	Sustain 50 deg. C for 24 hrs.	Demonstration	Independent Verification
Step 2	Reach 135 deg. C in 8 hrs.	Demonstration	Independent Verification
Step 3	Sustain 135 deg. C for 16 hrs.	Demonstration	Independent Verification
<b>3.3</b>	<b>Design and Construction</b>		
3.3.1	Production Drawings	Inspection	Conformance to drawings
<b>3.3.2</b>	<b>Manufacture</b>		
	Electrical	Inspection	Conformance to drawings
	Welding	Inspection	Per EM-002
<b>3.3.3</b>	<b>Workmanship</b>		
All	All	Inspection	